9.0 MARINE WATER QUALITY CRITERIA

The determination of "unreasonable degradation" of the marine environment is to be based on consideration of the ten criteria listed in Section 1.0. The following section provides information pertinent for the consideration of the ocean discharge criterion listed below:

- **Criterion #10:** "Marine water quality criteria developed pursuant to Section 304(a)(l)."

Marine water quality standards for the protection of designated beneficial uses of the waters of the state of Alaska have been promulgated (Alaska Administrative Code, 18 AAC Chapter 70). The state of Alaska marine water quality standards are established for the protection of designated beneficial uses of the receiving water. These uses include 1) water supply for aquaculture, seafood processing, and industrial uses, 2) water recreation including primary or contact recreation (e.g., swimming) and secondary recreation (e.g., boating), 3) growth and propagation of fish, shellfish, and other aquatic life, and 4) harvesting for consumption of raw mollusks or other raw aquatic life. The U.S. EPA has also promulgated water quality criteria for priority pollutants for marine and fresh waters of the State of Alaska pursuant to Section 304(a) (U.S. EPA 1992).

The primary discharges of concern for water quality impairment result from the discharge of solid wastes that may accumulate in the vicinity of the discharge and the discharge of soluble wastes. Soluble wastes include soluble organic matter and nutrients with the potential to reduce the dissolved oxygen levels of the receiving water, enhance the growth of attached algae and phytoplankton, and alter phytoplankton species composition. Chlorine and other disinfectant wastes are an additional concern when these products are used to sanitize seafood processing work areas and are then discharged without treatment to the receiving water.

In this section the potential discharge resulting from seafood processing operations is discussed in terms of its compliance with federal and state water quality criteria. The evaluation will rely on the modeling

case scenarios developed in Section 3.0 and historical evaluations of the effects of specific Alaska seafood processing discharges on receiving water quality.

Although Section 403(c) regulations of the Clean Water Act allow for the establishment of a 100-m (330-ft) radius mixing zone for the initial dilution of seafood processing effluent, such an allowance has not been made for permitted seafood processing discharges in Alaska. However, a zone-of-deposit (an established bottom zone where solids may accumulate) in the receiving water may be allowed at the discretion of, and within limits set by the Alaska Department of Environmental Conservation (ADEC). An allowance of no more than a one acre (0.40 ha) zone-of-deposit may be established in the new general permit. Therefore, the following evaluation will include a discussion of the potential formation of waste deposits in the vicinity of Alaskan seafood processing discharges and the potential effect of a waste deposit on overlying water quality.

The federal and state water quality standards that are relevant to the evaluation of potential adverse impacts of the discharge of seafood processing waste include:

- Zone-of-deposit
- Aesthetic qualities and floating material
- Turbidity
- Petroleum hydrocarbons, oil and grease
- Dissolved oxygen
- Toxic substances including residual chlorine, unionized ammonia, and undissociated sulfide

These standards are described and evaluated below.

In addition to the 403(c) regulations of the Clean Water Act (CWA), Section 303(d)(1) requires each state to identify those waters within its boundaries for which existing effluent limitations are not stringent enough to comply with applicable water quality standards or are not expected to meet water quality standards even after technology-based effluent limitations are applied. These waters are identified by placement on the 303(d) list. In addition, the state must establish a priority ranking for these waters, taking into account the severity of the pollution and the uses of the waterbodies. Section 305(b)(1) of

the CWA requires each state to prepare and submit to the U.S. EPA Regional Administrator a report [the 305(b) report] which provides the basis for the development of a state water quality management plan for those water bodies identified as impaired or water quality limited. The State of Alaska 305(b) report includes the following information every two years:

- A description of the water quality of all navigable waters in the state during the preceding year as well as an analysis to the extent to which all navigable waters provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife, and allow recreational activities in and on the water.

- A description of the nature and extent of nonpoint source pollution and recommendations of programs necessary to control nonpoint sources.

- An estimate of the environmental, economic, and social costs and benefits needed to achieve the objectives of the CWA.

The State of Alaska 303(d) list and 305(b) report are discussed and summarized in Section 9.7 below.

9.1 ZONE-OF-DEPOSIT

A zone-of-deposit may be allowed at the discretion of, and within limits set by ADEC. The water quality criteria and anti-degradation requirements of the Alaska water quality standards may be exceeded in a zone-of-deposit, but water quality standards must be met at every point outside of the zone-of-deposit. The water quality standards can not be violated in the water column outside of the deposit by any action, including leaching or suspension of deposited materials via chemical or physical means. The physical limits of the zone-of-deposit may be defined in a permit issued or certified under 18 AAC Chapter 70.015.

The ADEC, in deciding whether to allow a zone-of-deposit, considers:

- The alternatives that would eliminate, or reduce, any adverse effects of the deposit
- The potential direct and indirect impacts on human health
- The potential impacts on aquatic life and other wildlife, including the potential for bioaccumulation and persistence
- The potential impacts on other uses of the water body
- The expected duration of the deposit and any adverse effects
- The potential transport of pollutants by biological, physical, and chemical processes.

The ADEC has considered these items and has determined that a general permit containing an allowance for a zone-of-deposit of one acre (0.40 ha) could be certified under 18 AAC 70.015. The allowance for the depth and volume of the deposit would be indeterminate.

[Based on the modeling case scenarios.....recommendations for monitoring]

Although a variance can be issued to allow for a limited accumulation of seafood waste in the vicinity of the discharge, water quality criteria can not be exceeded in the water column immediately above the zone-of-deposit. Water quality criteria relevant to evaluating the potential adverse effects of wastepile decay on aquatic organisms include criteria for dissolved oxygen, unionized ammonia, and undissociated sulfide (see Section 3.1.3). The potential for the exceedance of these water quality criteria are discussed in the relevant sections below.

9.2 AESTHETIC QUALITIES AND FLOATING MATERIAL

In general, aesthetic water quality and floating material are regulated in the form of narrative standards. These standards differ somewhat depending on the designated marine water uses. For the growth and propagation of fish, shellfish, aquatic life, and wildlife the standard states the following:

> "Shall not, alone or in combination with other substances or wastes, make the water unfit or unsafe, or cause acute or chronic problem levels as determined by bioassay or other appropriate methods. Shall not, alone or in combination with other substances, cause a film, sheen, or discoloration on the surface of the water or adjoining shorelines; cause leaching of toxic or deleterious substances; or cause a sludge, solid, or emulsion to be deposited beneath or upon the surface of the water, within the water column, on the bottom, or upon adjoining shorelines."

Whether the aesthetic and floating material water quality standard will or will not be violated by a particular discharge depends on the depth of the discharge, the presence or absence of water column density stratification, and prevailing wind- and tidally-driven currents, as well as the physical and chemical characteristics of the effluent. Seafood waste discharges near the surface or at depth in relatively shallow, unstratified waters will generally tend to result in the surfacing of the discharge plume. Relatively small waste particles with densities at or below that of seawater (e.g., small bits of fat) will tend to float and may result in accumulations of waste particles near the surface. Depending on the prevailing currents, surface accumulations of waste may be driven onto nearby shorelines.

It is not possible to predict the potential for violation of this standard. However, surfacing plumes and foam were noted during U.S. EPA compliance inspections of several shore-based seafood processing facilities in 1991 (U.S. EPA 1991). The potential for accumulation of floating material on the water surface and shorelines can be minimized by locating the discharge well below the surface of the water and removing floatable material from the wastestream prior to discharge to the receiving waters.

9.3 TURBIDITY

Turbidity is regulated by numeric and narrative standards depending on the designated use of the water. For marine water supply and recreational uses the standard is 25 Nephelometric Turbidity Units (NTU) that should not be exceeded at any time. For the growth and propagation of fish, shellfish, aquatic life and wildlife, the standard is as follows:

> "Shall not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent. In addition, shall not reduce the maximum Secchi disk depth by more than 10 percent."

The standard for consumption of raw mollusks or other raw aquatic life is the same as stated above.

Whether or not the state turbidity standard will be violated depends on the initial dilution of the seafood wastewater and the optical properties of the solid waste particles and any dissolved organic matter. Because seafood processing waste effluent can contain an appreciable amount of suspended solids (see Section 2.5) the turbidity standard of 25 NTU may be exceeded during the initial mixing of the wastewater discharge. However, due to dilution and settling of particulate solids the turbidity following initial mixing is likely to be lower than the 25 NTU standard depending on the background turbidity of the receiving water. For example, the maximum turbidity measured in the wastewater plume from the Trident Seafoods-Akutan plant during a peak processing period was 48 NTU, but beyond the visible surface plume maximum turbidities were less than 6 NTU (Tetra Tech 1993).

Violations of the narrative standards for the compensation point for photosynthetic activity and Secchi depth will depend on the ambient conditions at each discharge location. However, considering the potential for exceedance of the turbidity standard, violation of the narrative standards will likely be confined to the area of any visible surface plumes. The potential for exceedance of this standard can be minimized by locating the discharge well below the water surface in relatively deep water.

9.4 PETROLEUM HYDROCARBONS, OILS AND GREASE

Oil and grease is regulated by numeric and narrative standards depending on the designated use of the water. Numeric criteria are established for the protection of water supplies for aquaculture and for the protection of growth and propagation of aquatic life and wildlife. For the protection of aquaculture water supplies the petroleum hydrocarbon or oil and grease concentration shall not exceed 0.01 times the continuous-flow 96-hour LC_{50} for the species involved. For the protection of the growth and propagation of aquatic life and wildlife, the total hydrocarbons in the water column shall not exceed 15 μg/L or 0.01 of the lowest measured continuous-flow 96-hour LC_{50}[2] for life stages of species identified by ADEC as the most sensitive, biologically important species in a particular location, whichever concentration is less. Also, total aromatic hydrocarbons in the water column shall not exceed 10 μg/L, or 0.01 of the lowest measured continuous-flow LC_{50} for life stages of species identified by ADEC as the most sensitive, biologically important species in a particular location whichever concentration is less. Furthermore, there shall be no concentrations of hydrocarbons, animal fats, or vegetable oils in the sediment which cause deleterious effects to aquatic life. Surface waters and adjoining shorelines shall be virtually free from floating oil, film, sheen or discoloration. For the protection of water recreation uses the discharge shall not cause a film, sheen, or discoloration on the surface or floor of the water body or adjoining shorelines and surface waters shall be virtually free from floating oils. For the protection of water supply for seafood processing and for harvesting and consumption of raw mollusks or other raw aquatic life the discharge shall not exceed concentrations which individually or in combination impart undesirable odor or taste to organisms as determined by bioassay and or organoleptic tests.

Although relatively small amounts of petroleum hydrocarbons derived from machinery lubricating oils may be discharged along with the seafood processing waste, the primary water quality concern is the creation of floating oil sheens derived from fish and shellfish fats and oils that are discharged as wastes. Some petroleum hydrocarbon releases associated with vessel and boat operations (e.g., refueling) may also occur. As with foam and floating material, the presence of a floating oil sheen will depend on the physical and chemical characteristics of the discharged wastewater and the receiving water.

---

[2] The LC_{50} is the concentration of a substance that is lethal to 50 percent of the organisms in a test population. The lower the LC_{50} the more potently toxic the substance. These toxicity tests used to determine the LC_{50} are typically conducted for a fixed period of exposure (e.g., 96 hours).

It is not possible to predict the potential for violation of this standard. However, no oil sheens were noted during U.S. EPA compliance inspections of several shore-based seafood processing facilities conducted in 1991 (U.S. EPA 1991). The potential for exceedance of the oil and grease standard can be minimized by locating the discharge well below the water surface in relatively deep water.

9.5 DISSOLVED OXYGEN

Numeric dissolved oxygen standards have been established for the protection of marine water uses. These standards state that surface dissolved oxygen concentrations in coastal waters shall not be less than 6.0 mg/L for a depth of one meter except when natural conditions cause this value to be depressed. Furthermore, dissolved oxygen shall not be reduced below 4.0 mg/L at any point beneath the water surface. Dissolved oxygen concentrations in estuaries and tidal tributaries shall not be less than 5.0 mg/L except where natural conditions cause this value to be depressed.

To evaluate the potential for exceedance of the state dissolved oxygen standard due to seafood wastewater discharges, the dissolved oxygen concentration following initial dilution and the farfield dissolved oxygen concentration was calculated using the method outlined by the U.S. EPA (1982). This method is applicable to wastewater discharges to open coastal waters, but may not be applicable to discharges to relatively sheltered bays or estuaries. Dissolved oxygen concentrations below 6.0 mg/L were only predicted for the two most conservative cases (Table 9-3). These cases were for receiving waters with an ambient dissolved oxygen concentration of 7.0 mg/L, an initial dilution of 10, a Brooks' n equal to 1 (i.e., linearly increasing horizontal diffusivity), and a BOD_5 concentrations of 155 and 6,850 mg/L (the median and maximum BOD_5 concentrations reported for the total effluent group in Table TD1. Because dissolved oxygen concentrations of the cold marine waters of Alaska are typically greater than 7.0 mg/L, violations of the state standard for dissolved oxygen are not predicted to occur unless ambient receiving water dissolved oxygen concentrations are much below 8.0 mg/L.

Dissolved oxygen concentrations may also be depleted near the surface of decaying bottom accumulations of seafood waste due to bacterial oxidation of the seafood waste. Chemical oxidation of the reduced by-products of bacterially-mediated waste decay (e.g., methane and sulfide) also act to reduce water column dissolved oxygen concentrations above decaying seafood wastepiles. Seafood wastepile modeling studies

of a relatively large wastepile accumulation [approximately 1.2 ha (3.0 ac) or more] in Akutan Harbor, Alaska, a harbor with restricted water exchange, indicated that oxygen consumed by wastepile decay and decay byproducts did not reduce ambient dissolved oxygen concentrations by more than 6-7 percent (Tetra Tech 1986). Therefore, it is unlikely that smaller wastepile accumulations of 0.40 ha (1.0 ac) or less in well flushed coastal waters will cause a significant depression of ambient water column concentrations of dissolved oxygen or result in exceedances of marine water quality criteria for dissolved oxygen.

9.6 TOXICS AND OTHER DELETERIOUS ORGANIC AND INORGANIC SUBSTANCES

The State of Alaska numeric standards for the protection of marine water uses state that substances shall not individually or in combination exceed 0.01 times the lowest measured 96-hour LC_{50} for life stages of species identified by ADEC as being the most sensitive, biologically important to the location, or exceed criteria cited in EPA, *Quality Criteria for Water* (U.S. EPA 1986) or *Alaska Drinking Water Standards* (18 AAC Chapter 80), whichever concentration is less. Furthermore, the standard states that substances shall not be present or exceed concentrations which individually or in combination impart undesirable odor or taste to fish or other aquatic organisms as determined by either bioassay or organoleptic test. Although the U.S. EPA (1992) has promulgated marine water quality criteria for the State of Alaska for priority toxic pollutants, the toxic pollutants of concern for seafood processing waste (i.e., residual chlorine, unionized ammonia, and undissociated sulfide) are not classified as priority toxic pollutants. Therefore, only the State of Alaska marine water quality criteria (Alaska Administrative Code; 18 AAC Chapter 70.020) and the U.S. EPA-recommended criteria (U.S. EPA 1986), including the criteria update for saltwater unionized ammonia criteria (U.S. EPA 1988), are used in the evaluation of criteria for residual chlorine, unionized ammonia, and undissociated sulfide.

9.6.1 Total Residual Chlorine

Disinfectants, including chlorine-based products, are used in the seafood processing industry to destroy potential disease-causing microorganisms that could contaminate finished seafood products destined for human consumption. The Food and Drug Administration (FDA) has proposed regulations to ensure the safe processing of fish and fishery products to reduce the hazards to human health (FDA 1994). The

proposed FDA regulations mandate frequent[3] cleaning (through the use of alkaline detergents) and disinfection (through the use of hypochlorites, iodophors, and quarternary ammonium compounds) of seafood processing utensils, equipment, and processing areas to minimize microbiological contamination of seafood products [21 CFR 123.10]. However, associated with the benefits of disinfection are potential adverse effects associated with the reaction of chlorine and chlorine compounds with organic matter and ammonia in the wastewater. Disinfectant reaction byproducts include potentially carcinogenic chlorinated organic compounds and toxic forms of chlorinated ammonia and chloroamines. In freshwater, chlorine reacts with water to form hypochlorous acid, hypochlorite ion, and other reactive forms that include mono- and dichloroamines. These reactive forms are termed "residual chlorine". In seawater, chlorine also reacts with bromide to form hypobromous acid, hypobromite ion, and bromamines. Therefore, the term "chlorine-produced oxidants" is used to refer to the residual chlorine forms measured in seawater.

Marine water quality standards for chlorine have been established by the State of Alaska. The most restrictive numeric standards for total residual chlorine established by the state are for the protection of water supply for aquaculture and for growth and propagation of aquatic life and wildlife. The State of Alaska standard states that the total residual chlorine concentration shall not exceed 2.0 μg/L for salmonid fish, or 10.0 μg/L for other organisms. The recommended federal criteria for residual chlorine concentrations in marine waters states that saltwater and their uses should not be affected unacceptably if the 4-day average concentration (i.e., chronic criterion) of chlorine-produced oxidants does not exceed 7.5 μg/L more than once every 3 years on the average and if the one-hour average concentration does not exceed 13 μg/L more than once every 3 years on the average (U.S. EPA 1985). Therefore, the State of Alaska water quality standard is more restrictive than the recommended federal standard.

Because the complexity of the reactions of chlorine in fresh and marine waters (Carpenter and Smith 1980; Johnson 1980) it is difficult to assess the potential adverse effects of the intermittent application of disinfectants to seafood processing areas. No data are available on the typical amounts and rates of application of active disinfectant ingredients in a typical Alaskan seafood processing facility (see Section 2.0). However, it is likely that residual chlorine concentrations in the effluent discharged to the receiving water is low considering the following:

[3]For example, the proposed FDA regulations mandate cleaning and disinfection every four hours for cooked or ready to eat seafood products.

- The equipment to be disinfected is first washed to remove much of the visible organic residue and contamination to minimize the quantity of disinfectant required

- The disinfectants are applied in diluted form only to the areas to be disinfected

- The process wastewater effectively dilutes residual disinfectant concentrations

- The remaining residual chlorine compounds remaining after equipment disinfection are reduced when they contact the high concentration of readily oxidized organic waste matter in the wastestream.

Based on the available residual chlorine measurements made on seafood processing wastewater presented in Section 2.7, these assumptions are probably valid. The available monitoring results presented in Section 2.7 indicate that residual chlorine is frequently below analytical detection limits. However, the analytical detection limits achieved and the method used to measure the chlorine residual were not provided. The method used to measure residual chlorine is very important due to the potential positive and negative bias introduced by interfering compounds and specific methods are required to measure chlorine-produced oxidants in wastewaters containing seawater (American Public Health Association 1992). Because of the potential toxicity of residual chlorine compounds derived from the disinfection of seafood processing areas, continued effluent monitoring is recommended. Specific monitoring recommendations for the measurement of residual chlorine are provided in Section 11.0.

9.6.2 Unionized Ammonia

Unionized ammonia can be toxic to marine organisms. The concentration of unionized ammonia depends on the total ammonia concentration and the salinity, temperature, and pH of the water. A relatively conservative estimate of the criteria maximum concentration (acute criterion) for total ammonia appropriate to marine waters of Alaska, based on a salinity of 30 ppt, pH of 8.2, and water temperature of 15^{0} C, is 6.7 mg N/L. A relatively conservative estimate of the criteria continuous concentration (chronic criterion) for total ammonia, based on a salinity of 30 ppt, pH of 8.2, and water temperature of 15^{0} C, is 1.0 mg N/L.

Sources of ammonia attributable to seafood processing discharges include ammonia dissolved in the seafood processing wastewater and ammonia released from the decaying waste organic matter in the water column or from seafood waste that has accumulated on the bottom.

Review of water quality studies conducted in confined bays in the vicinity of active Alaskan seafood processing discharges (Tetra Tech 1993; Tetra Tech 1986; Jones & Stokes Associates and Tetra Tech 1984; Feder and Burrell 1979; U.S. EPA 1976) indicates that maximum water column total ammonia concentrations have not exceeded 0.750 mg/L. Therefore, it is unlikely that discharges of seafood processing wastes to open coastal waters will pose a threat of unionized ammonia toxicity to aquatic organisms.

Ammonia nitrogen is also produced by the bacterially-mediated decay of seafood waste, particularly during the anaerobic decay of seafood wastepile accumulations (see Section 3.1.3). Although Tetra Tech (1987) attempted to develop a simple wastepile decay model to predict the concentration of ammonia nitrogen above a seafood wastepile in Akutan Harbor, AK, the model predicted higher water column concentrations of total ammonia (greater than 1.0 mg/L) than were actually measured above the wastepile (0.22 mg/L). Overestimation of ammonia released from decaying organic matter using simple stoichiometric models has been noted in other studies (e.g., Almgren et al. 1975). Additional loss processes not considered by this model included nitrification and assimilation of the released ammonia. These processes likely reduce the actual concentration of total ammonia to concentrations below levels predicted to be harmful to marine organisms. Therefore, it is unlikely that exceedances of the water quality criteria for unionized ammonia occur due to seafood wastepile accumulations of 0.40 ha (1.0 ac) or less.

9.6.3 Undissociated Sulfide

Hydrogen sulfide (H_2S) is produced by the anaerobic decay of organic matter by bacteria that use sulfate as an electron acceptor (see Section 3.1.3). In seawater most of the hydrogen sulfide (approximately 97.5 percent) dissociates to HS^- and H^+ at the pH, temperature, and salinity of Alaskan marine waters (Tetra Tech 1987; Goldhaber and Kaplan 1975). The remaining undissociated sulfide (approximately 2.5 percent) can be toxic to marine organisms. The saltwater chronic criterion for undissociated sulfide is 2.0 μg/L. There is no undissociated sulfide acute criterion established for regulatory purposes.

Because hydrogen sulfide in marine water occurs primarily in the dissociated form, and because hydrogen sulfide is also rapidly oxidized to sulfate in sea water (Almgren and Hagström 1974), undissociated sulfide concentrations above seafood waste piles are expected to be below water quality standards, except possibly just above the waste pile (Tetra Tech 1987). The undissociated hydrogen sulfide concentrations within the pile likely occur at concentrations that exceed water quality criteria, especially in anaerobic zones of the waste pile where oxidation of the released hydrogen sulfide does not occur.

9.7 ALASKAN MARINE WATERS THAT ARE WATER QUALITY LIMITED

In accordance with the requirements of the CWA, the State of Alaska has identified those waters which are water quality limited due to a variety of pollutants [i.e., the 303(d) list]. Two waterbodies on the list, Akutan Harbor and Unalaska Bay, were designated as water quality limited due to fish waste residues (State of Alaska 305(b) report, Table 1). Additionally, those waters which are of monitoring interest in accordance with Section 305(b) of the CWA are also listed. Waterbodies currently included on this list due to seafood processing wastes are: Wrangell Narrows (Petersburg), Orca Inlet (Cordova), and Resurrection Bay (Seward) in Southeast Alaska; St. Paul's Harbor and Gibson Cove on Kodiak Island; South Unalaska Bay, Dutch Harbor, Captains Bay, and Akutan Harbor in the Aleutian Islands; and Naknek River (King Salmon/Naknek) in Bristol Bay (State of Alaska 305(b) report, Table B-1).

9.8 SUMMARY

The potential for exceedances of relevant state and federal water quality criteria due to the discharge of seafood processing waste to coastal marine waters of the State of Alaska was evaluated. Relevant criteria include a proposed zone-of-deposit of 0.40 ha (1.0 ac), aesthetic qualities and floating material, turbidity, oil and grease, dissolved oxygen, and toxic substances, including residual chlorine, unionized ammonia, and undissociated sulfide. In general, it is unlikely that exceedances of the relevant State of Alaska or federal marine water quality criteria will be caused by seafood waste discharges regulated under the new NPDES general permit, with one possible exception. The exception is state aesthetic criteria for accumulations of floating material in the vicinity of discharges and shoreline accumulations of floating seafood

waste. The allowance for a 0.40 ha (1.0 ac) zone-of-deposit is not predicted to cause exceedances of the relevant criteria (i.e., dissolved oxygen, unionized ammonia, undissociated sulfide).

Because of the uncertainty associated with the prediction of the exceedance of the 0.40 ha (1.0 ac) zone-of-deposit, monitoring for the presence and areal extent of seafood waste accumulations in the vicinity of seafood processors covered under the new NPDES general permit is recommended. Because of the potential toxicity of disinfectants used in the maintenance of sanitary conditions in seafood processing areas, and the quality of currently available data, monitoring of wastewater residual chlorine concentrations is also recommended. Specific monitoring recommendations are provided in Section 11.0.

10.0 DETERMINATION OF UNREASONABLE DEGRADATION

Section 1.0 of this ODCE provides the regulatory definition of unreasonable degradation of the marine environment (40 CFR 125.121[e]) and indicates the ten criteria which are to be considered when making this determination (40 CFR 125.122). The actual determination of whether the discharge will cause unreasonable degradation is made by the U.S. EPA Regional Administrator. The intent of this section is to briefly summarize information pertinent to the determination of unreasonable degradation with respect to the ten criteria.

10.1 CRITERION 1

The quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged.

- It is estimated that approximately 80 percent of the seafood processing facilities that will likely be covered under the new NPDES general permit annually discharge 12 million pounds or less of seafood processing solid waste. These facilities also discharge soluble wastes that include biochemical oxygen demand, the nutrients nitrogen and phosphorus, and diluted disinfectant solutions, as well as other miscellaneous waste waters.

- The quantity and character of seafood processing wastes varies seasonally depending on the species processed and the types of products that are produced.

- Although seafood processing wastes do not contain significant quantities of pollutants that may bioaccumulate in aquatic organisms, and therefore do not pose a long-term threat to the health of aquatic organisms or humans, solid wastes have been observed to accumulate and persist in the vicinity of seafood processing waste discharges.

10.2 CRITERION 2

The potential transport of such pollutants by biological, physical, or chemical processes.

- The extent of the initial accumulation of solid waste on the bottom depends on the height of the discharge above the seafloor, current speed, and the settling velocities of the waste particles. The extent of bottom waste accumulation over the long-term depends primarily on the decay rate of the waste organic matter and the degree of resuspension and transport of the deposited waste.

- Soluble wastes from these discharges are expected to be rapidly diluted or degraded by biological, physical, and chemical processes.

10.3 CRITERION 3

The composition and vulnerability of the biological communities which may be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the Endangered Species Act, or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain.

- Benthic communities within the 1 acre zone of deposit may be adversely impacted by smothering or anoxic conditions due to decay of the accumulated organic wastes. Benthic communities outside the zone of deposit may also be impacted due to subtle changes in community composition and structure.

- A worst case analysis for the deposition of seafood wastes covered by the new NPDES general permit (321 acres of bottom covered by seafood waste piles) indicates that much less than 0.0001 percent of the Alaskan coastal waters would receive deposition of organic wastes in amounts thought to have an adverse impact on benthic communities [i.e. 1 cm (0.4 in)].

- Cetaceans found in Alaskan waters currently identified as endangered species pursuant to the Endangered Species Act (ESA) include the following: blue, bowhead, fin, gray, humpback, northern right, sei, and sperm whales. There are no cetaceans currently identified as a threatened species. The Steller sea lion, which occurs from southeast Alaska to the Bering Strait, is listed as a threatened species pursuant to the ESA. Marine birds identified as endangered species include the American peregrine falcon and the short-tailed albatross. Marine birds and waterfowl presently identified as threatened species include the Aleutian Canada goose, Arctic peregrine falcon, and the spectacled eider. The Snake River sockeye salmon and Snake River spring/summer and fall chinook salmon are presently identified as endangered and threatened species, respectively. The discharge of seafood processing wastes are not likely to adversely effect the following species: blue, bowhead, gray, northern right, and sei whales, Steller sea lion, American and Arctic peregrine falcons, short-tailed albatross, Snake River sockeye salmon, and Snake River spring/summer and fall chinook salmon. The humpback, fin, and sperm whales have the potential to be impacted by discharges due to reduction in prey. The Aleutian Canada goose has the potential to be impacted from increased localized populations of gulls and parasitic birds which may adversely effect breeding success.

10.4 CRITERION 4

The importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the life cycle of an organism.

- There are numerous areas in the Alaskan coastal waters that are important areas for a variety of species, ranging from phytoplankton to marine mammals. Areas in the Chukchi Sea include most coastal waters. These areas are used by a variety marine mammals for migration and feeding. The Bering Sea is also an important area for many species including crab species, many commercial fish species, and many marine birds and mammals. Bristol Bay and the Yukon-Kuskokwim Delta are important areas for sockeye salmon, seabirds and waterfowl.

- The Aleutian Islands and the Pribilof Islands, in particular, are very important areas for marine mammals and seabirds. The Pribilof Islands support approximately 72 percent of the entire North Pacific breeding population of northern fur seals. In addition, the Pribilof Islands support one of the largest colonies of nesting seabirds in the Bering Sea. St George Island supports possibly the largest thick-billed murre colony in the world and is also the primary nesting area for most of the world's population of red-legged kittiwakes.

- Shelikof Strait/Cook Inlet is a known migratory route for gray whales and a possible migratory route for fin and humpback whales. This area is also a major spawning area for walleye pollock. Cook Inlet and Kachemak Bay are important areas for killer whales, beluga whales, Dall's porpoises, and harbor porpoises. Sea otters utilize the Kenai Peninsula, Kodiak Island, and Cook Inlet areas. Steller sea lions utilize the entire coastal area, with Shelikof Strait being a particularly critical habitat resource area.

- Areas of major significance to waterfowl include lower and upper Cook Inlet, Kodiak Island, and the eastern side of the Alaska Peninsula. Kachemak Bay, Shelikof Strait, and the Barren Islands are important resource areas for many seabirds. In the Gulf of Alaska, important areas include Copper River Delta, Prince William Sound and several bays in Cook Inlet. The largest concentration of waterfowl during spring and fall are found in the Kenai Lowlands, Trading Bay, Redoubt Bay, and Fox River Flats.

- Kamishak Bay, Kachemak Bay, and part of Shelikof Strait are nurseries for Tanner crab as well as important habitats for King and Dungeness crabs.

10.5 CRITERION 5

The existence of special aquatic sites including, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs.

- There are eight national wildlife refuges (Alaska Maritime, Alaska Peninsula, Becharof, Izembek, Kenai, Kodiak, Togiak, and Yukon Delta), twelve state game refuges and sanctuaries (Anchorage Coastal, Cape Newenham, Goose Bay, Mendenhall Wetlands, Palmer Hay Flats, McNeil River, Susitna Flats, Trading Bay, Yakataga, McNeil River, Stan Price, and Walrus Islands), six national parks and preserves (Bering Land Bridge, Katmai, Kenai Fjords, Lake Clark, Wrangell-St. Elias, and Glacier Bay), and two national monuments (Aniakchak and Cape Krusenstern), which exist in the vicinity of potential seafood processing activities.

- There are twelve state designated Critical Habitat Areas (CHA) which exist in the vicinity of potential seafood processing wastes discharges: Cinder River, Clam Gulch, Copper River Delta, Egegik, Fox River Flats, Kachemak Bay, Kalgin Island, Pilot Point, Port Heiden, Port Moller, Redoubt Bay, and Tugidak.

- The National Marine Fisheries Service has designated critical habitat for the Steller sea lion pursuant to the Endangered Species Act. Specific sites include: all Steller sea lion rookeries and major haulouts (> 200 sea lions) located within state and federally managed waters off Alaska, including a zone that extends 0.9 km (3,000 ft) landward and vertical of each rookery and haulout boundary, and that extends 0.9 km (3,000 ft) seaward from rookeries and major haulouts located east of 144° W longitude, or 20 m seaward from rookeries and major haulouts west of 144° W longitude, and one aquatic foraging zone located exclusively in the Gulf of Alaska and two aquatic zones located in the Bering Sea/Aleutian Islands area. All of Shelikof Strait has been designated as critical habitat. Air zones extending 0.9 km (3,000 ft) above these terrestrial and aquatic zones have also been designated as critical habitat

- The Alaska Coastal Management Program authorizes a mechanism for focusing attention to areas of a borough which are critical to the borough's needs and where potential conflicts are likely to occur. This process is initiated by nomination of an Area Meriting Special Attention (AMSA). There are over 20 locations either receiving the AMSA designation or which have been nominated for future designation.

10.6 CRITERION 6

The potential impacts on human health through direct and indirect pathways.

- Seafood processing waste discharges are not expected to result in significant impacts to human health. These discharges do not contain significant quantities of pollutants that bioaccumulate in aquatic organisms, and therefore seafood processing discharges will not result in elevated levels of toxic or carcinogenic pollutants in marine organisms consumed by humans.

10.7 CRITERION 7

Existing or potential recreational and commercial fishing, including finfishing and shellfishing.

- Nearshore locations used for recreational and subsistence fisheries are predominately outside areas with the potential to be impacted by seafood processing waste discharges under the limitations and conditions set forth in the proposed NPDES general permit.

- Commercial fisheries in Alaska include: salmon, groundfish (chiefly walleye pollock, Pacific cod, and Pacific halibut), herring, Tanner, Dungeness, and king crabs, clams, shrimp, scallops, and abalone. Seafood waste discharges may potentially adversely impact stocks of walleye pollock and Pacific cod. The likelihood of impacts to these species is strongly dependent on the timing, composition, quantity, and location of discharges, although the overall impact is expected to be minimal. Other species commercially harvested are not expected to be impacted.

10.8 CRITERION 8

Any applicable requirements of an approved Coastal Zone Management Plan.

- Discharges associated with seafood processing wastes covered under the proposed NPDES general permit are expected to be consistent with relevant Alaska Coastal Management Program and district policies under the limitations and conditions set forth in the general permit with the following provisions: discharges are avoided in areas containing significant concentrations of shellfish, waterfowl, shorebird, or marine mammal habitat or harvest areas, and floating processors shall not be located within 152.4 m (500 ft) of the mouth of any anadromous fish stream within the boundaries of the borough of Angoon.

- Nearshore locations used for subsistence fisheries are predominately outside areas that may be impacted by activities conducted during exploratory drilling. Therefore, discharges associated with oil and gas exploration in the Lease Sale area are expected to be consistent with relevant Borough policies.

10.9 CRITERION 9

Such other factors relating to the effects of the discharge as may be appropriate.

- Concerns have been raised about potential indirect effects of the discharge of seafood processing waste on marine organisms. These indirect effects include the following:

  - Nutrient enrichment of coastal waters which may result in enhanced biomass of phytoplankton and alteration of plankton species composition. Toxic phytoplankton species may occur more frequently and at higher levels under these conditions resulting in adverse effects to aquatic organisms, and potentially to human health.

- The attraction of marine mammals to waste discharges which makes them easier prey for predators.

- The attraction of seabirds to waste discharges which may result in a number of adverse effects that range from oiling, enhancement of the numbers of species of gulls that may adversely affect threatened or endangered bird species, and adverse effects on birds that consume decaying, bacterially contaminated seafood waste.

There is currently no documented scientific evidence that these effects have or will cause unreasonable degradation of the marine environment. However, these concerns are valid and provide general hypotheses that could be addressed by directed scientific studies.

10.10 CRITERION 10

Marine water quality developed pursuant to Section 304(a) of the Clean Water Act.

- The regulated discharge of seafood processing waste is expected to comply with relevant water quality criteria.

10.11 DATA GAPS

While the information contained in this ODCE is intended to provide the basis for the determination of unreasonable degradation, it should be cautioned that some data gaps exist in the understanding of the fate, transport, and effect of seafood processing waste discharges. More exact estimates of the settling velocities of seafood waste particles and waste decay rates are needed to improve the model predictions of the bottom accumulation of seafood solid waste. Field tests of the model predictions should also be conducted. In addition, uncertainty exists regarding the indirect impacts of seafood processing wastes, especially to marine mammals and aquatic birds. It is recommended that research be conducted to address these data gaps.

11.0 MONITORING RECOMMENDATIONS

Effluent and receiving water monitoring is recommended for seafood processing discharges that will be covered under the new NPDES general permit. Monitoring is recommended to ensure compliance with permit stipulations and limits, and to improve the existing database on the quantity and character of seafood processing waste discharges, the transport, fate, and persistence of the discharged waste, potential adverse impacts to aquatic organisms, and compliance with applicable water quality standards. Specific monitoring recommendations are outlined below.

11.1 SEAFOOD PROCESSING FACILITY CHARACTERISTICS

Basic information should be provided by each permittee that will allow the U.S. EPA to characterize the location and type of each processing facility and the physical characteristics of the waste discharge outfall.

Seafood processing facilities should report the following information:

- All facilities should provide the facility or vessel name, address or P.O. Box number, a phone/facsimile number, the type of facility according to the definition in the new general permit, and a general description of the typical species processed and the types of seafood products produced (i.e., *shore-based*, *nearshore*, or *offshore seafood processor*. The types of seafood processing wastewater treatment, in addition to grinding (e.g., screening), that are applied to the discharge should also be described.

- *Shore-based* and *nearshore seafood processors* discharging from a fixed location should report the distance of the facility from shore, the latitude and longitude of the end of the permitted waste discharge outfall, the water depth at MLLW at the point of discharge, and the height of the discharge above the bottom.

- *Offshore* and *nearshore seafood processors* that do not discharge at fixed locations should report the distance of the facility from shore when the facility discharges seafood waste, the general area or region where the discharge occurs, the range of water depths where the discharge occurs, and the depth below the surface at MLLW to the end of the discharge pipe.

11.2 WASTE DISCHARGE MONITORING

Information should be provided by each permittee that will allow the U.S. EPA to characterize the quality and quantity of solid and liquid wastes discharged by facilities covered under the new permit.

Seafood processing facilities should report the following information:

- The mass (wet weight) of waste solids discharged each month and the single-day maximum waste solids discharged during each month based on facility-specific product recovery rates. The waste discharge estimate should include any discarded species that are passed through the wastehandling system without processing.

- Estimates of the percent of the monthly total and single-day maximum solids waste discharge contributed by specific seafood products and the identification of the products produced should be summarized based on facility-specific product recovery rates. The estimate should include the percent of discarded species discharged through the wastehandling system.

- The ground waste discharge should also be inspected weekly to determine compliance with the limitation that all solid waste be ground to 1.3 cm (0.5 in) or less. The extent of periods of non-compliance and reasons for non-compliance should be reported.

- The monthly average and single-day maximum wastewater flow rate of the final effluent (i.e., including both liquid and solid waste) should be reported.

- The effluent total residual chlorine concentration should be measured on at least one wastewater sample representative of process area disinfectant use collected during each month of operation. The EPA-approved method 4500-Cl G (DPD Colorimetric Method) (APHA 1992) is recommended for wastes with high organic matter content. The actual laboratory method used and any modifications required to correct the data for interfering substances should be described. The results should not be corrected for additional oxidants (i.e., bromine and bromamines) that may be produced in the presence of seawater. The results should be reported as chlorine-produced oxidants. If the concentration of chlorine-produced oxidants is below the laboratory detection limit, the laboratory detection limit should be reported.

- If the facility operates a secondary wastewater treatment plant for the treatment of sanitary wastes, monthly measurements of the TSS and BOD_5 concentration in samples collected from the treated secondary wastewater effluent should be reported.

- Certification should be provided if the facility uses a U.S. Coast Guard-approved marine sanitation device for sanitary wastewater treatment, or if the sanitary waste is discharged to a municipal wastewater treatment system.

11.3 RECEIVING WATER MONITORING

Information should be provided by each permittee that will allow determination of compliance with water quality criteria. The focus of receiving water monitoring should be on the documentation of any solid seafood waste accumulation on the bottom in the vicinity of the discharge, the occurrence and extent of floating waste material accumulations on the water surface or along the shore, and the occurrence and extent of oil sheens on the water surface. Specifically, seafood processing facilities should provide the following information:

- *Shore-based seafood processing facilities* should provide a reasonably accurate estimate of the areal extent of seafood waste solids accumulation on the bottom in the vicinity of the discharge. A single survey conducted between peak processing periods should be

adequate. The survey should by conducted visually by divers. The survey should at a minimum determine the maximum length of the wastepile and the maximum width perpendicular to the long axis of the wastepile. The depth of the deposited waste should be recorded at approximately 1-m (3.3 ft) intervals along each transect. Based on these data the permittee should estimate and report the total areal coverage and volume of the wastepile.

- Visual inspections of the receiving water and shoreline within 500 m (0.3 mi) of the discharge should be conducted to determine the presence or absence of accumulations of floating material or oil sheens on the water surface or along the shoreline. The periods and areal extent of visible floating material or oil sheens should be documented and reported.

11.4 ADDITIONAL CONSIDERATIONS

Additional considerations that may be beyond the scope of the general permit monitoring requirements include data that would provide the basis for the refinement of the WASP5 seafood waste deposition model and directed scientific studies of the relative importance of indirect impacts of seafood processing waste discharges on phytoplankton communities and marine mammals and birds. These studies are briefly outlined below.

11.4.1 Refinement of the WASP5 Seafood Waste Deposition Model

A mathematical model has been developed to predict the deposition and accumulation of seafood solid waste in the vicinity of seafood processing facilities discharging from a fixed location. Using this model a first-approximation was made of the annual seafood solid waste discharge rate that would create a 0.40 ha (1.0 ac) bottom waste accumulation in the absence of resuspension and transport for 12 hypothetical model case scenarios. However, only first-approximations were possible for a number of the variables used in the model. Of particular importance are the estimates of particle settling velocities and the first-order waste decay rate. Field and modeling studies of particular facilities should be conducted to refine and test the predictions made by the model.

Field tests should be conducted at selected facilities where resuspension and transport of the deposited waste is expected to be minimal. Field measurements should include recording of current speeds and direction during several months of the year, measurement of the settling velocities of ground seafood waste particles, and the characteristics of the discharge (e.g., height of the discharge above the bottom, solid waste discharge rates). By accurately measuring these variables and minimizing the influence of resuspension and transport of the deposited solids, a better approximation of the model waste decay rate can be made. The calibrated model can then be tested using data from another representative facility.

Because resuspension and transport is an additional loss mechanism that is not considered in the WASP5 seafood waste deposition model, additional effort should be directed toward the assessment and possible development of models that are capable of predicting the resuspension and transport of deposited seafood solid waste.

11.4.2 Investigations of Potential Indirect Effects of Seafood Processing Waste Discharges

A number of potential indirect effects to marine organisms due to the discharge of seafood processing waste have been identified (see Section 5.0). However, there is currently no documented scientific evidence that these effects have or will cause unreasonable degradation of the marine environment. However, these concerns provide general hypotheses that could be addressed by well designed scientific studies. Specifically, studies should be conducted to address the following hypotheses:

- Seafood processing waste discharges as regulated under the new general permit alone or in combination cause nutrient enrichment of coastal waters which results in enhanced biomass of phytoplankton or alteration of plankton species composition.

- Seafood processing waste discharges as regulated under the new general permit alone or in combination cause toxic phytoplankton species to occur more frequently or in higher concentrations which result in adverse effects to aquatic organisms, and potentially to human health.

- Seafood processing waste discharges as regulated under the new general permit alone or in combination attract and concentrate marine mammals which results in significantly increased mortality of these animals due to increased vulnerability to predators.

- Seafood processing waste discharges as regulated under the new general permit alone or in combination result in the attraction of marine birds to waste discharges which cause a number of adverse effects as a result of oiling, enhancement of the numbers of species of gulls that may adversely affect threatened or endangered bird species, and adverse effects on birds that consume decaying, bacterially contaminated seafood waste.

12.0 REFERENCES

Alaska Biological Research (ABR). 1993. Endangered Species Act: An update. In: AB Research Notes, 4 pp.

Aleutians East Borough. 1992. Aleutians East Borough Coastal Management Program. Prepared by Jon Isaacs and Associates and Resource Analysts.

Aleutians East Coastal Resource Service Area. 1984. Resource Inventory for the Aleutians east Coastal Resource Service Area, Vol. II. Prepared by Resource Analysts, Eagle River, AK.

Aleutians West Coastal Resource Service Area. 1991. Aleutians West Coastal Resource Service Area Coastal Management Plan. Prepared by Resource Analysts, Anchorage, AK.

Aller, R.C. 1982. The effect of macrobenthos on chemical properties of marine sediment and overlying water. pp. 53-104. In: Animal-sediment relations. P.L. McCall and M.J.S. Tevesz (eds). Plenum Press, NY.

Almgren, T. and I. Hagström. 1974. The oxidation rate of sulphide in sea water. Water Research 8:395-400.

Almgren, T., L.-G. Danielsson, D. Dyrssen, T. Johansson, and G. Nyquist. 1975. Release of inorganic matter from sediments in a stagnant basin. Thalassia Jugoslavica 11:19-29.

Ambrose, S. 2 February 1994. Personal Communication (letter to Mr. Gregory Kellogg, U.S. EPA, Region 10, Wastewater Management and Enforcement Branch, Seattle, WA). U.S. Fish and Wildlife Service, Fairbanks, AK.

Ambrose, R.B., Jr., T.A. Wool, J.P. Connolly, and R.W. Schanz. 1988. WASP4, a hydrodynamic and water quality model—Model theory, user's manual, and programmer's guide. EPA/600/3-87-039. Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Athens, GA.

American Public Health Association (APHA). 1992. Standard methods for the examination of water and wastewater. 18th Edition. American Public Health Association, Washington, D.C.

Anderson, D.M. 1989. Toxic algal blooms and red tides: A global perspective. pp. 11-16. In: Red tides: Biology, environmental science, and toxicology. Proceedings of the first international symposium on red tides held November 10-14, 1987, Takamatsu, Kagawa Prefecture, Japan. T. Okaichi, D.M. Anderson, and T. Nemoto (eds). Elesevier, NY.

Anderson, M. 1974. Predation and kleptoparasitism by skuas in a Shetland seabird colony. Ibis 118: 208-217.

Anderson, D.M and A.W. White (eds). Toxic dinoflagellates and marine mammal mortalities. Proceedings of an expert consultation held at the Woods Hole Oceanographic Institution. Woods Hole Oceanographic Institution, Wooods Hole, MA.

Aubert, M. 1990. Mediators of microbiological origin and eutrophication phenomena. Mar. Pollut. Bull. 21:24-29.

Babbitt, J.K. 1982. Utilization research division monthly progress report. March. National Marine Fisheries Service, Seattle, WA. (not seen)

Baird, P.A., and P.J.H. Gould (eds). 1983. The breeding biology and feeding ecology of marine birds in the Gulf of Alaska. U.S. DOC, NOAA, OCSEAP Final Report 45 (1986): 121-504.

Baird, R. 14 April 1994. Personal Communication (memo from the National Marine Fisheries Service regarding the U.S. position of bowhead whale taking for subsistence purposes).

Barry, S.J. and T.W. Barry. 1990. Food habits of Glaucous gulls in the Beaufort Sea. Arctic 43:43-49.

Billen, G. 1982. An idealized model of nitrogen recycling in marine sediments. Am. Jour. Sci. 282:512-541.

Blackburn, J.E. 1979. Pelagic and Demersel Fish Assessment in the lower Cook Inlet estuary system. pp. 107-382 Environmental assessment of the Alaskan continental shelf, Vol. 17. Biological Studies. NOAA/MMS, Boulder, CO.

Bouchet, G. C. 1983. Estimation of the abundance of Dall's porpoise (*Phocoenoides dalli*) in the North Pacific Ocean and Bering Sea by strip transect methodology, 1978-1983. International Whaling Commission. SC/35/SM/Z, June 1983. 19 pp.

Breiwick, J.M. and H.W. Braham. 1984. The status of endangered whales. Mar. Fish. Rev. 46(4): 1-64.

Bristol Bay Coastal Resource Service Area Board. 1982. Bristol Bay Coastal resource Service Area Coastal Management Plan. Billingham, AK.

Brooks, N.H. 1960. Diffusion of sewage effluent in an ocean current. pp. 246-267. In: Proc. 1s International Conference on Waste Disposal in the Marine Environment, Berkeley, CA. July, 1959. Permagon Press, NY.

Byrd, G.V. 1992. Current Breeding Status of the Aleutian Canada goose, a recovering endangered species. In: Biology and management of Canada geese. Proceed. Intern. Canada Goose Symposium. U.S. Fish and Wildlife Service, NAS Adak, AK.

Calkins, D.G. 1987. Marine mammals. pp. 527-558 D.W. Hood and S.T. Zimmerman, eds., The Gulf of Alaska: Physical environment and biological resources. (Order number PB87-103230). U.S. Department of Commerce, Springfield, VA. 655 pp.

Calkins, D.G. 1992. Steller sea lions: Still threatened in Alaska. Alaska's Wildlife. pp. 22-26.

Calkins, D.G., and K.B. Schneider. 1985. Species account: The sea otter (*Enhydra lutris*). Alaska Department of Fish and Game.

Calkins, D. and E. Goodwin. 1988. Investigation of the declining sea lion population in the Gulf of Alaska. August 15. Alaska Department of Fish and Game, Anchorage, AK.

Caretta, J.V., M.S. Lynn, and C.A. LeDuc. 1994. Right whale (*E. glacialis*) sighting off San Clemente Island, California. Mar. Mam. Sci. 10: 101-104.

Carpenter, J.H. and C.A. Smith. 1980. Reactions in chlorinated seawater. pp. 195-207. In: Water chlorination—Environmental impact and health effects. Volume 2. R.L. Jolley (ed). Ann Arbor Science, Ann Arbor, MI.

City of Angoon. 1990. Angoon Coastal Managment program. Angoon, AK.

City of Bethel. 1983. Bethel Coastal Management Plan. Conceptually Approved Draft. Planning Department, City of Bethel, Bethel, AK.

City of Pelican. 1994. Pelican Coastal Management Program. Prepared by E.T. Maki, M. Bixby, and P. McKay.

City of Valdez. 1986. Valdez Coastal management Program. Prepared by the Community Development Department, City of Valdez, AK.

Cooney, R.T. 1987. Common zooplankton and micronekton for oceanic and shelf regions, Kodiak and lower Cook Inlet. pp. 285-303 D.W. Hood and S.T. Zimmerman, eds., The Gulf of Alaska: physical environmental and biological resources. U.S. DOC, Springfield, VA. 655 pp.

Cosper, E.M, C. Lee, and E.J. Carpenter. 1990. Novel "brown tide" blooms in Long Island embayments: A search for the causes. pp. 17-28. In: Toxic marine phytoplankton. E. Granéli, B. Sundtröm, L. Edler, and D.M. Anderson (eds). Elsevier, NY.

Crapo, C. 1988. Final report on the characterization of Alaska seafood wastes. Prepared for Alaska Fisheries Development Foundation. University of Alaska, Fishery Industrial Technology Center, Kodiak, AK.

Crapo, C., B. Paust, and J. Babbitt. 1993. Recoveries and yields from Pacific fish and shellfish. Alaska Sea Grant College Program, University of Alaska Fairbanks, Fairbanks, AK.

Crawford, T.W. 1981. Vertebrate prey of *Phocoenoides dalli* (Dall's porpoise) associated with the Japanese high seas salmon fishery in the North Pacific Ocean. M.S. Thesis, University of Washington. Seattle, WA. 72 pp.

Crawford, D.L., D.K. Law, and J.K. Babbitt. 1972. Nutritional characteristics of marine food fish carcass waste and machine-separated flesh. J. Agr. Food Chem. 20:1048 (not seen).

Dames & Moore. 1978. Drilling fluid dispersion and biological effects study for the Lower Cook Inlet C.O.S.T. Well. Prepared for Atlantic Richfield Company. Dames & Moore, Anchorage, AK. 309 pp.

Damkaer, D.M. 1977. Initial zooplankton investigations in Prince William Sound, Gulf of Alaska, and lower Cook Inlet. pp. 137-274 Environmental assessment of the Alaskan continental shelf. Annual; reports of principal investigations for the year ending March 1977. Vol. X: Receptors - fish, littoral benthos. NOAA/BLM, Boulder, CO.

Dau, C.P. and S.A. Kistchinski. 1977. Seasonal movements and distribution of the spectacled eider. Wildfowl 28: 65-75.

Donaldson, J.R. 1967. The phosphorus budget of Iliamna Lake, Alaska as related to the cyclic abundance of sockeye salmon. Ph.D. thesis. College of Fisheries, University of Washington, Seattle, WA.

Faris, T. 1993. Biological information for anadromous fish species that NMFS is responsible for that are present in Alaska and listed as threatened or endangered. National Marine Fisheries Service, Juneau, Ak.

Feder, H.M. and D.C. Burrel. 1979. Impact of seafood cannery waste on the benthic biota and adjacent waters at Dutch Harbor. Institute of Marine Science, University of Alaska Fairbanks, Fairbanks, AK.

Feder, H.M. 1981. Distribution, abundance, community structure, and tophic relationships of the nearshore benthos of Cook Inlet. pp. 45-676. Environmental assessment of the Alaskan continental shelf. Final reports of principal investigators. Vol. 14: Biological studies. NOAA/BLM, Boulder, CO.

Food and Drug Administration (FDA). 1994. 21 CFR Parts 123 and 12400. Proposal to establish procedures for the safe processing and importing of fish and fishery products; proposed rule. Department of Health and Human Services, Food and Drug Administration, Washington, D.C. Federal Register Vol. 59, pp. 4142-4214.

Froelich, P.N., G.P. Klinkhammer, M.L. Bender, N.A. Luedtke, G.R. Heath, D. Cullen, and P. Dauphin. 1975. Early oxidation of organic matter in pelagic sediments of the eastern equatorial Atlantic: suboxic diagenesis. Geochim. Cosmochim. Acta 43:1075-1090.

Gardner, R. 3 May 1994. Personal Communication (phone by Ms. Kimberle Stark, Tetra Tech, Inc., Redmond, WA). Lake and Peninsula Borough. King Salmon, AK.

Geraci, J.R. 1989. Investigation of the 1987-88 mass mortality of bottlenose dolphins along the U.S. Central and South Atlantic coast. Prepared for National Marine Fisheries Service, Office of Naval Research, and Marine Mammal Commision. Wildlife Disease Section, Department of Pathology, Ontario Veterinary Colloge, University of Guelph, Guelph, Ontario, Canada.

Geraci, J.R., D.M. Anderson, R.J. Timperi, D.J. St. Aubin, G.A. Early, J.H. Prescott, and C.A. Mayo. 1989. Humpback whales (*Megaptera novaeangliae*) fatally poisoned by dinoflagellate toxin. Can. J. Fish. Aquat. Sci. 46:1895-1898.

Giger, M. 6 April 1994. Personal Communication (letter to Mr. Burney Hill, U.S. Environmental Protection Agency, Region 10, Seattle, WA). U.S. Fish and Wildlife Service.

Gilmartin, W.G., R.L. DeLong, A.W. Smith, L.A. Griner, and M.D. Dailey. An investigation into unusual mortality in the Hawaiian monk seal, *Monachus schaauinslandi*. In: Proceedings of the symposium on status of resource investigations in the northwestern Hawaiian Islands, April 24-25, 1980, University of Hawaii, Honolulu, HI. R.W. Grigg and R.T. Pfund (eds). University of Hawaii Sea Grant College Program, Honolulu, HI.

Goldhaber, M.B. and I.R. Kaplan. 1975. Apparent dissociation constants of hydrogen sulfide in chloride solutions. Mar. Chem. 3:83-104.

Gould, P.J., D.J. Forsell, and C.J. Lensink. 1982. Pelagic distribution and abundance of seabirds in the Gulf of Alaska and eastern Bering Sea. National Fishery Research Center. Anchorage, Ak.

Haigh, R. and F.J.R. Taylor. 1990. Distribution of potentially harmful phytoplankton species in the Northern Strait of Georgia, British Columbia. Can. J. Fish. Aquat. Sci. 47:2339-2350.

Hale, S.S. 1972. Some reactions of the ocean quahog *Arctica islandica* upon burial. Mimeo report. University of Rhode Island, School of Oceanography, Kingston, RI.

Harper, D.E., Jr. and G. Guillen. 1989. Occurrence of a dinoflagellate bloom associated with an influx of low salinity water at Galveston, Texas, and coincident mortalities of demersal fish and benthic invertebrates. Contributions in Marine Science 31:147-161.

Henrichs, S.M. and A.P. Doyle. 1986. Decomposition of ^{14}C-labeled organic substances in marine sediments. Limnol. Oceanogr. 31:765-778.

Hughes, W.A. 1983. Cube Cove marine infauna investigations - September 1983. U.S. Fish and Wildlife Service, Juneau, AK. 28 pp.

Incze, L.S., A.W. Kendall, J.D. Schumacher, and R.K. Reed. 1989. Interactions of a mesoscale patch of larval fish (*Theragra chalcogramma*) with the Alaska Coastal Current. Continental Shelf Research 9(3):269-284.

Jahnke, R.A. 1990. Early diagenesis and recycling of biogenic debris at the seafloor, Santa Monica Basin, California. J. Mar. Res. 48:413-436.

Johnson, J.D. 1980. Measurement and persistence of chlorine residuals in natural waters. pp. 37-63. In: Water chlorination—Environmental impact and health effects. Volume 1. R.L. Jolley (ed). Ann Arbor Science, Ann Arbor, MI.

Jones & Stokes Associates and Tetra Tech. 1984. Effects of seafood waste deposits on water quality and benthos, Akutan Harbor, Alaska. Prepared for U.S. Environmental Protection Agency, Region 10, Seattle, WA. Jones & Stokes Associates, Inc. and Tetra Tech, Inc., Bellevue, WA.

KPB (Kenai Peninsula Borough). 1990. Kenai Peninsula Borough Coastal Management Program. Kenai Peninsula Borough Resource Planning Department, Soldotna, AK.

KPB (Kenai Peninsula Borough). 1992. Port Graham/Nanwalek area which merits special attention plan. Kenai Peninsula Borough Resource Planning Department, Soldotna, AK.

Kendall, A., J. Dunn, and R. Wolotira. 1980. Zooplankton including ichthyoplankton and decapod larvae of the Kodiak Shelf. Northwest Alaska Fisheries Center Report 80-8.

Kendall, A., and T. Nakatani. 1992. Comparisons of early life history characteristics of walleye pollock in Shelikof Strait, Gulf of Alaska, and Funka Bay, Hokkaido, Japan. Fish Bulletin 90: 129-138.

Kinoshita, R.K., B.M.K. Brooke, L.E. Queirolo, and J.M. Terry. 1991. Draft report. Economic status of the groundfish fisheries off Alaska, 1991. Socioeconomic Task, Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA.

Kizevetter, I.V. 1971. Chemistry and Technology of Pacific Fish. Translated from Russian by IPST staff. U.S. Dept. of Commerce, National Technical Information Service, Springfield, VA. (not seen)

Kodiak Island Borough. 1984. Kodiak Island Borough Coastal Management Program. Kodiak, AK.

Kranz, P.M. 1974. The anastrophic burial of bivalves and its paleoecological significance. Journal of Geology 82:237-265.

Larrance, J.D., D.A. Tennant, A.J. Chester, and P.A. Ruffio. 1977. Phytoplankton and primary productivity in the northeastern Gulf of Alaska and lower Cook Inlet. pp. 1-136 Environmental assessment of the Alaskan continental shelf. Annual reports of principal investigation for the year ending March 1977. Col. X: Receptors NOAA/BLM, Boulder, CO.

Legendre, L. 1990. The significance of microalgal blooms for fisheries and for the export of particulate organic carbon in oceans. J. Plankton Res. 12:681-699.

Lloyd, C., M.L. Tasker, and K. Partridge. 1991. The status of seabirds in Britian and Ireland. Nature Conservancy Council and the Seabird Group. T & A D Poyser, London.

Loefflad, M. 1 April 1994. Personal Communication (E-mail memo to Sue Mello, National Marine Fisheries Service, Anchorage, AK). National Marine Fisheries Service, Seattle, WA.

Loughlin, T.R. 1989. Status of Northern Sea Lions. Proceeding of the Gulf of Alaska, Cook Inlet, and North Aleutian Basin information update meeting, Feb. 7-8, 1989. OSCEAP study MMS-89-0041.

MMC (Marine Mammal Commission). 1989. Annual report of the Marine Mammal Commission, Calendar Year 1989.

Martin, M. and T.W. Barry. 1978. Nesting behavior and food habits of parasitic jaegers at Anderson River Delta, Northwest Territories. Canadian Field-Naturalist 92: 45-50.

Mauer, D.L., R.T. Keck, J.C. Tinsman, W.A. Leathem, C.A. Wethe, M. Huntzinger, C. Lord, and T.M. Church. 1978. Vertical migration of benthos in simulated dredged material overburdens. Vol. I: Marine benthos. Technical Report D-78-35. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

McGurk , M.D. 1989. Relationships of growth and survival of pacific herring to environmental factors Proceedings of the Gulf of Alaska, Cook Inlet, and North Aleutian Basin information update meeting, Feb 7-8, 1989. OCSEAP Study MMS-89-0041.

Mendenhall, V. 1993. Monitoring of populations and productivity of seabirds at Cape Peirce, Bluff, and Cape Thompson, Alaska, 1990. Outer Continental Shelf Environmental Assessment Program, Final Report. Submitted to MMS, Environmental Studie Unit, Anchorage, AK. OCS Study MMS 92-0047.

Mendenhall, V. and H. Milne. 1985. Factors affecting duckling survival of Eiders *Somateria mollissima* in northeast Scotland. IBIS 127: 148-158.

Meyers T.F. 1977. Effects of logging study: A summary of NMFS activities. National Marine Fisheries Service, Environmental Assessment Division, Juneau, AK. 63 pp.

Mills, M.J. 1992. Harvest, catch, and participation in Alaska sport fisheries during 1991. Alaska Department of Fish & Game.

Morris, R. 16 August 1993. Personal Communication (telephone with Ms. Kimberle Stark, Tetra Tech, Inc., Redmond, WA). National Marine Fisheries Service, Anchorage, AK.

Munro, J. and J. Bedard. 1977. Gull predation and Creching behavior inthe common eider. J. Anim. Ecol. 46:799-810.

National Marine Fisheries Service (NMFS). 1989. Marine Mammal Protection Act of 1972, Annual Report 1988-1989. U.S. Department of Commerce, National Oceanic and Atmospheric Adminstration, National Marine Fisheries Service, Office of Protected Resources, Silver Springs, MD.

National Marine Fisheries Service (NMFS). 1991a. Endangered whales: Status update. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Silver Springs, MD.

National Marine Fisheries Service (NMFS). 1991b. Endangered and threatened species; Endangered Status for Snake River sockeye salmon. NMFS. Federal Register Vol. 56, No. 224. pp. 58619-58624.

National Marine Fisheries Service (NMFS). 1991c. Endangered and threatened species; Proposed threatened status for Snake River spring/summer chinook salmon. NMFS. Federal Register Vol. 56, No. 124. pp. 29542-29552.

National Marine Fisheries Service (NMFS). 1992. Endangered and threatened species; Threatened status for Snake River spring/summer chinook salmon, threatened status for Snake River fall chinook salmon. NMFS. Federal Register Vol. 57, No. 78. pp. 14653-14663.

National Marine Fisheries Service (NMFS). 1993a. Endangered fish and wildlife; Gray whale. National Marine Fisheries Service, Silver Springs, MD. Federal Register Vol 58(4): 3121-3126.

National Marine Fisheries Service (NMFS). 1993b. Designated critical habitat; Steller sea lion. NOAA, NMFS. Federal register Vol. 58, No. 165. pp. 45269-45285.

National Marine Fisheries Service (NMFS). 1993c. Final conservation plan for the northern fur seal (*Callorhinus ursinus*). Prepared by the National Marine Mammal Laboratory/Alaska Fisheries Science Center, Seattle, WA, and the Office of Protected Resources/National Marine Fisheries Service, Silver Spring, MD. 80 pp.

Nettleship, D.N. 1977. Seabird resources of eastern Canada: Status, problems, and prospects. In: Proc. Sympo. on Can. Threatened Species and Habitats, Can. Nat. Fed. T. Mosquin and C. Suchal, (eds). pp 96-108.

North Pacific Fishery Management Council. 1989. Non-utilization in the groundfish fisheries off Alaska. Discussion Paper 89-1. Prepared by Council Staff and the Bering Sea/Aleutian Islands and Gulf of Alaska Groundfish Plan Teams. Anchorage, AK.

Nowell, A.R.M., P.A. Jumars, and J.E. Eckman. 1981. Effects of biological activity on the entrainment of marine sediments. pp. 133-153. In: Developments in sedimentology 32. Sedimentary dynamics of continental shelves. C.A. Nittrouer (ed). Elsevier Scientific Publishing Company, NY. Reprinted from Marine Geology 42(1/4).

O'Shea, T.J., G.B. Rathbun, R.K. Bonde, C.D. Buergelt, D.K. Odell. 1991. An epizootic of Florida manatees associated with a dinoflagellate bloom. Marine Mammal Science 7:165-179.

Oliver, J.S. and P.N. Slattery. 1973. Dredging, dredge spoil disposal and benthic invertebrates in Monterey Bay. Moss Landing Marine Laboratory Report. Monterey, CA. 130 pp.

Pacific Associates. 1993. Discards in the groundfish fisheries of the Bering Sea/Aleutian Islands & the Gulf of Alaska during 1992. Prepared for Alaska Department of Fish & Game.

Pearson, T.H. and R. Rosenberg. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanogr. Mar. Biol. Annu. Rev. 16:229-311.

Piquelle, S.J., and B.A. Megrey. 1993. A preliminary spawning biomass estimate of walleye pollock *Theragra chalcogramma*, in the Shelikof Strait, Alaska, based on the annual egg production method. Bull. Mar. Sci. 53(2):728-749.

Redfield, A.C. 1958. The biological control of chemical factors in the environment. Am. Sci. 46:206-226.

Redfield, A.C., B.H. Ketchum, and F.A. Richards. 1963. The influence of organisms on the composition of seawater. pp. 26-77. In: The Sea. Volume 2. M.N. Hill (ed). Wiley-Interscience, NY.

Saila, S.B., S.D. Pratt, and T.T. Polgar. 1972. Dredge spoil disposal in Rhode Island Sound. University of Rhode Island Marine Technical Report No. 2. 48 pp.

Savikko, H. 3 March 1994. Personal Communication (phone by Curtis DeGasperi, Tetra Tech, Inc., Redmond, WA). Alaska Department of Fish & Game, Juneau, Ak.

Savikko, H. and E. Simpson. 1994. An overview of preliminary run forecasts and harvest projections for 1994 Alaska salmon fisheries and review of the 1993 season. Regional Information Report No. 5J94-01. Commercial Fisheries Management and Development Division, Alaska Department of Fish and Game, Juneau, AK.

Schafer, W. 1972. Ecology and paleoecology of the marine environment. G.Y. Craig (ed.). Trans. Chicago Univ. Press, IL. 568 pp.

Schroeder, R.F., D.B. Anderson, R. Bosworth, J.M. Morris, and J.M. Wright. 1987. Subsistence in Alaska: Arctic, Interior, Southcentral, Southwest, and Western Regional summaries. Alaska Department of Fish & Game. Technical paper no. 150. 690 pp.

Schumacher, J.D. and A. Kendall. 1989. Fisheries oceanography coordinated investigations (FOCI). walleye pollock recruitment in the western Gulf of Alaska Proceedings of the Gulf of Alaska, Cook Inlet, and North Aleutian Basin information update meeting, Feb 7-8, 1989. OCSEAP study MMS-89-0041.

Scientific Applications, Inc. (SAIC). 1977. Environmental assessment of the Alaskan continental shelf. Annual reports summary for the year ending March 1977. Prepared for NOAA/3LM, Boulder, CO.

Scientific Applications, Inc. (SAIC). 1979. Environmental assessment of the Alaskan continental shelf - lower Cook Inlet interim synthesis report. Prepared for NOAA/BLM, Boulder, CO. 241 pp.

Seifert, D. and L.S. Incze. 1991. Zooplankton of Stelikof Strait, Alaska, April and May 1989. Data from Fisheries Oceanography Coordinated Investigations (FOCI) cruises. Northwest Alaska Fisheries Center Report 91-16.

Seitz, J. 1993. Cordova. pp. 15-44. In: An Investigation of the Sociocultural Consequences of Outer Continental Shelf Development in Alaska. J.A. Fall and C.J. Utermohle (eds.). Alaska Department of Fish & Game, Anchorage, AK.

Shimizu, Y. 1989. Toxicology and pharmacology of red tides: An overview. pp. 17-21. In: Red tides: Biology, environmental science, and toxicology. Proceedings of the first international symposium on red tides held November 10-14, 1987, Takamatsu, Kagawa Prefecture, Japan. T. Okaichi, D.M. Anderson, and T. Nemoto (eds). Elesevier, NY.

Sleath, J.F.A. 1984. Sea bed mechanics. John Wiley & Sons, NY. 335 pp.

Smayda, T.J. 1990. Novel and nuisance phytoplankton blooms in the sea: Evidence for a global epidemic. pp. 29-40. In: Toxic marine phytoplankton. E. Granéli, B. Sundtröm, L. Edler, and D.M. Anderson (eds). Elsevier, NY.

Smayda, T.J. and P. Fofonoff. 1989. An extraordinary, noxious brown-tide in Narragansett Bay. II. Inimical effects. pp. 133-136. In: Red tides: Biology, environmental science, and toxicology. Proceedings of the first international symposium on red tides held November 10-14, 1987, Takamatsu, Kagawa Prefecture, Japan. T. Okaichi, D.M. Anderson, and T. Nemoto (eds). Elesevier, NY.

Smayda, T.J. and A.W. White. 1990. Has there been a global expansion of algal blooms? If so, is there a connection with human activities? pp. 516-517. In: Toxic marine phytoplankton. E. Granéli, B. Sundtröm, L. Edler, and D.M. Anderson (eds). Elsevier, NY.

Spallinger, A. 27 July 1993. Personal Communication (phone by Ms. Kimberle Stark, Tetra Tech, Inc., Redmond, WA). Alaska Department of Fish & Game, Anchorage, AK.

Springer, P.F. 1993. Population, distribution, and ecology of migrating and wintering Aleutian Canada geese. Humboldt State University Foundation, Arcata, CA.

Stehn, R.A., C.P. Dau, B. Conant, and W.I. Butler, Jr. 1993. Decline of spectacled eiders nesting in western Alaska. Arctic 46: 264-277.

Sternberg, R.W. 1972. Predicting initial motion and bed transport of sediment particles in the shallow marine environment. pp. 61-82. In: Shelf sediment transport—process and pattern. D.J.P. Swift, D.B. Duane, and O.H. Pilkey (eds). Dawden, Hutchinson & Ross, Inc., Stroudsburg, PA. 656 pp.

Stevens, B.G. and J.A. Haaga. 1994. Draft manuscript. Ocean dumping of seafood processing wastes: Comparisons of epibenthic megafauna sampled by submersible in impacted and non-impacted Alaskan bays, and estimation of waste decomposition rate. National Marine Fisheries Service, Kodiak Laboratory, Kodiak, AK.

Stoker, S. 1981. Benthic invertebrate macrofauna of the eastern Bering/Chukchi continental shelf. In: The Eastern Bering Sea Shelf: Oceanography and Resources. D.W. Hood and J.A. Calder (eds). NOAA/OMPA, Seattle, WA. Vol. 2, pp. 1069-1090.

Straley, J.M., C.M. Gabriela, and C.S. Baker. 1994. Annual reproduction by individually identified humpback whales (*Megaptera novaeanglia*) in Alaskan waters. Mar. Mam. Sci. 10: 87-92.

Sundström, B., L. Edler, and E. Granéli. 1990. The global distribution of harmful effects of phytoplankton. pp. 537-541. In: Toxic marine phytoplankton. E. Granéli, B. Sundtröm, L. Edler, and D.M. Anderson (eds). Elsevier, NY.

Swanson, G.R., E.G. Dudley, and K.J. Williamson. 1980. The use of fish and shellfish wastes as fertilizers and feedstuffs. pp. 281-327. In: Handbook of organic waste conversion. M.W.M. Bewick (ed). Van Nostrand Reinhold Company, NY.

Taylor, F.J.R. 1990. Red tides, brown tides and other harmful algal blooms: The view into the 1990's. pp. 527-533. In: Toxic marine phytoplankton. E. Granéli, B. Sundtröm, L. Edler, and D.M. Anderson (eds). Elsevier, NY.

Tetra Tech. 1986. Evaluation of seafood processing waste disposal—Akutan Harbor, Alaska. Prepared for Trident Seafoods Corporation and Deep Sea Fisheries, Inc., Seattle, WA. Tetra Tech, Inc., Bellevue, WA.

Tetra Tech. 1987. Response to comments on: Evaluation of seafood processing waste disposal—Akutan Harbor, Alaska. Prepared for Trident Seafoods Corporation and Deep Sea Fisheries, Inc., Seattle, Wa. Tetra Tech, Inc., Bellevue, WA.

Tetra Tech. 1992. Initial survey of the seafood processing industry in Alaska, Washington, and Oregon. Prepared for U.S. Environmental Protection Agency, Region 10, Seattle, WA. Tetra Tech, Inc., Bellevue, WA. (attached in this report as Appendix A).

Tetra Tech. 1993. Akutan Harbor water quality study—September 1993. Volume 1: Data summary report. Prepared for U.S. Environmental Protection Agency, Region 10, Ocean Programs Section, Seattle, WA. Tetra Tech, Inc., Redmond, WA.

Tetra Tech. 1994. Final Ocean Discharge Criteria Evaluation for area of coverage under the Arctic NPDES general permit for oil and gas exploration. Prepared for U.S. Environmental Protection Agency, Region 10. Tetra Tech, Inc., Redmond, WA.

Thatcher, T.O. 1980. The relative sensitivity of Pacific Northwest fishes and invertebrates to chlorinated sea water. pp. 341-350. In: Water chlorination—Environmental impact and health effects. Volume 1. R.L. Jolley (ed). Ann Arbor Science, Ann Arbor, MI.

Thomann, R.V. and J.A. Mueller. 1987. Principles of surface water quality modeling and control. Harper & Row, Publishers, NY. 644 pp.

Tromble, G. 1 June 1994. Personal Communication (phone by Curtis DeGasperi, Tetra Tech, Inc., Redmond, WA). Fishery Management Division, National Marine Fisheries Service, Juneau, AK.

Truett, J.C. 1984. Ecological characterization and biological use of lagoons in the eastern Beaufort Sea, Alaska. U.S. Dept. Commerce, NOAA, OCSEAP Final Report 24: 129-579.

Turekian, K.K., G.J. Benoit, and L.K. Benninger. 1980. The mean residence time of plankton-derived carbon in a Long Island sediment core: a correction. Estuarine, and Coastal Marine Science 11:583.

Tyler, H. 1975. Common terns, Arctic terns, and roseate terns in Maine. Prepared for the Maine Critical Areas Program.

U.S. Department of Interior/Minerals Management Service (U.S. DOI/MMS). 1984. Gulf of Alaska/ Cook Inlet Sale 88. Final Environmental Impact Statement. OCE EIS MMS 84-0023. U.S. DOI, MMS, Alaska OCS Region, Anchorage, AK.

U.S. Department of Interior/Minerals Management Service (U.S. DOI/MMS). 1990. Commercial fishery industry of the Bering Sea. Tech. Report No. 138., MMS 90-0026. U.S. Department of Interior/Minerals Management Service. 279 pp.

U.S. Department of Interior/Minerals Management Service (U.S. DOI/MMS). 1992. Outer continental shelf natural gas and oil resource management, Comprehensive Program 1992-1997. Final Environmental Impact Statement. OCS EIS/EA MMS92-0004. U.S. Department of Interior, MMS, Alaska OCS Regions, Anchorage, AK.

U.S. Environmental Protection Agency (U.S. EPA). 1975. Development document for effluent limitations guidelines and new source performance standards for the fish meal, salmon, bottom fish, clam, oyster, sardine, scallop, herring, and abalone segment of the canned and preserved fish and seafood processing industry point source category. EPA 440/1-75/041a, Group I, Phase II. U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (U.S. EPA). 1976. Survey of industrial wastewater discharge effects on water quality at Dutch Harbor, Alaska—October 9, 1975. Alaska Operations Office and Region 10 Surveillance and Analysis Division, U.S. Environmental Protection Agency, Seattle, WA. 61 pp.

U.S. Environmental Protection Agency (U.S. EPA). 1982. Revised Section 301(h) technical support document. EPA 430/9-82-011. Office of Water Program Operations, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (U.S. EPA). 1983. Draft Ocean Discharge Criteria Evaluation, Cook Inlet/Shelikof Strait OCS Lease Sale 60. U.S. EPA, Region X, Seattle, WA.

U.S. Environmental Protection Agency (U.S. EPA). 1984a. Final ocean discharge criteria evaluation, Diapir Field OCS Lease Sale 87 and state Lease Sales 39, 43, and 43a. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

U.S. Environmental Protection Agency (U.S. EPA). 1984b. Effects of seafood waste deposits on water quality and benthos. U.S. Environmental Protection Agency, Region 10, Seattle, WA. 81 pp. + appendices.

U.S. Environmental Protection Agency (U.S. EPA). 1985. Ambient water quality criteria for chlorine — 1994. EPA 440/5-84-030. Office of Water Regulations and Standards, Criteria and Standards Division, U.S. Environmental Protection Agency, Washington, D.C. 57 pp.

U.S. Environmental Protection Agency (U.S. EPA). 1986. Quality criteria for water. EPA 440/5-86-001. Office of Water Regulations and Standards, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (U.S. EPA). 1987. A simplified deposition calculation (DECAL) for organic accumulation near marine outfalls. EPA 430/09-88-001. Office of Marine and Estuarine Protection, U.S. Environmental Protection Agency, Washington, D.C. 49 pp. + appendices.

U.S. Environmental Protection Agency (U.S. EPA). 1988. Ambient water quality criteria for ammonia (saltwater). EPA 440/5-88-004. U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (U.S. EPA). 1991. Compliance reports for shore-based Alaskan seafood processors in Cordova, Ketchikan, Sitka, and Valdez, Alaska. Environmental Services Division, U.S. Environmental Protection Agency, Region 10, Compliance Inspection files, Seattle, WA.

U.S. Environmental Protection Agency (U.S. EPA). 1992. Water quality standards; establishment of numeric criteria for priority toxic pollutants; State's compliance. U.S. Environmental Protection Agency, Washington, D.C. Federal Register Vol. 57, No. 246, pp. 60848-60923.

U.S. Fish and Wildlife Service (U.S. FWS). No date. Fact sheet: The spectacled eider. U.S. Fish and Wildlife Service, Fairbanks, AK. 2 pp.

U.S. Fish and Wildlife Service (U.S. FWS). 1987. National Wildlife Refuges of Alaska. U.S. FWS, Anchorage, AK.

U.S. Fish and Wildlife Service (U.S. FWS). 1988. Alaska Maritime National Wildlife Refuge summary. Final Comprehensive Conservation Plan, Wilderness Review and Environmental Impact Statement. U.S. FWS, Anchorage, AK. 175 pp.

U.S. Fish and Wildlife Service (U.S. FWS). 3 July 1989. Personal Communication (letter to Mr. James Brennan, National Marine Fisheries Service, Silver Springs, MD). U.S. FWS, Atlanta, GA.

U.S. Fish and Wildlife Service (U.S. FWS). 1993. Endangered and threatened wildlife and plants; Proposal to remove the Arctic peregrine falcon from the list of endangered and threatened wildlife. U.S. FWS, Fairbanks, AK. Federal Register Vol. 58, No 188. pp. 51035-51045.

United Nations. 1986. Environmental assessment and management of the fish processing industry. Sectoral Studies Series No. 28. Sectoral Studies Branch, Studies and Research Division.

United Nations. 1990. Review of potentially harmful substances. Nutrients. IMO/FAO/UNESCO/ WMO/WHO/IAEA/UN/UNEP. Reports and Studies No. 34. United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris, France.

Vanoni, V.A (ed). 1977. Sedimentation engineering. Prepared by the ASCE Task Committee for the Preparation of the Manual on Sedimentation. Sedimentation Committee of the Hydraulics Division, American Society of Civil Engineers, NY.

Vollenweider, R.A. 1985. Elemental and biochemical composition of plankton biomass; some comments and explorations. Arch. Hydrobiol. 105:11-29.

Weast, R.C. (ed). 1982. Handbook of chemistry and physics. 63rd Edition. CRC Press, Boca Raton, FL.

Westrich, J.T. and R.A. Berner. 1984. The role of sedimentary organic matter in bacterial sulfate reduction: the G-model tested. Limnol. Oceanogr. 29:236-249.

Wilber, P. 1992. Case studies of the thin-layer disposal of dredged material-Fowl river, Alabama. Environmental Effects of dredging, Vol. D-92-5. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Wolfe, R.J. and R.G. Bosworth. 1990. Subsistence in Alaska: A summary. Division of Subsistence, Alaska Department of Fish & Game, Juneau, AK.

Zimmerman, S. 1 April 1994. Personal Communication (letter to Ms. Jeanette Carriveau, U.S. EPA. Region 10, Water Permits Section, Seattle, WA). National Marine Fisheries Service, Juneau, AK.